

2. Magnetite inclusions. Magnetite occurs as single, sometimes euhedral grains in the matrix, but also in complex intergrowths with other phases, *i.e.*, metal (kamacite and taenite), sulfide, cohenite and graphite. The grain size is 10 to 100 microns. Often metal forms the core and magnetite the outer part of an inclusion, suggesting formation of the magnetite by oxidation.

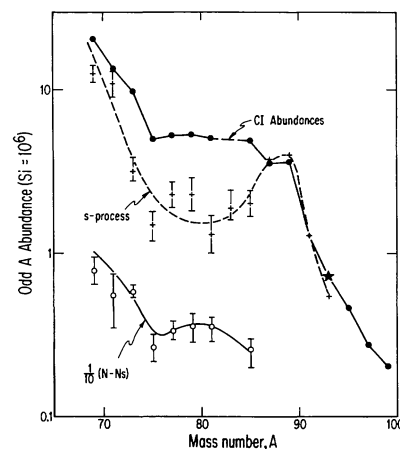
Magnetite and graphite are also found as magnetite-graphite aggregates in some unequilibrated ordinary chondrites, but on a much finer, submicron scale (2). However, coarse-grained magnetite-carbide assemblages were observed by Taylor *et al.* (3) in "two of the least metamorphosed" LL-chondrites, Semarkona (type 3.0) and ALH 77278 (type 3.6). Study Butte is, in contrast, a breccia, which contains equilibrated components (H-type chondrules, lithic clasts of higher petrologic type, differentiated lithic fragments) and unequilibrated components (chondrules with low and variable Fe/Fe + Mg and clear igneous glass).

All components were apparently assembled on the surface of a parent body, as Study Butte is gas-rich (H. Weber, personal communication, 1987). Al-rich and magnetite-carbide inclusions are usually considered to be condensates from the solar nebula. This implies that these primary components were still available and were mixed with processed, equilibrated material from the parent body, when Study Butte formed. It is difficult to understand, however, how the primary material survived the multiple compaction, equilibration, break-up and reworking processes, which must have occurred. It seems likely that the inclusions were also altered in this process. Or were they produced on the surface of the parent body? References: (1) Fredriksson K., Clarke R. S. Jr. and Pugh R. (1984) *Meteoritics* **19**, 225. (2) Scott E. R. D., Taylor, G. J., Rubin A. E., Okada A. and Keil K. (1981) *Nature* **291**, 544. (3) Taylor G. J., Okada A., Scott E. R. D., Rubin A. E., Huss G. R. and Keil K. (1981) *Lunar and Planetary Science* **12**, 1076.

**Interpretation of Solar System Abundances Around the  $N = 50$  Neutron Shell.** D. S. Woolum<sup>1</sup> and D. S. Burnett<sup>2</sup> <sup>1</sup>Dept. of Physics, Calif. State Univ., Fullerton, CA 92634 USA. <sup>2</sup>Geol. & Planet. Sci., Caltech, Pasadena, CA 91125 USA.

New measurements [1] of CI chondrites for Ni-Ru show a high degree of smoothness of the odd- $A$  solar system abundance curve (SSAC) through the region of the  $N = 50$  closed neutron shell. The resolved  $s$ - and  $r$ -process peaks at the  $N = 82$  and 126 neutron shells [2] are not apparent for the  $N = 50$  region. Our data confirm the necessity for a single element  $^{89}\text{Y}$  SSAC peak, presumably of  $s$ -process origin. If the total SSAC is smooth but made of contributions from more than one nucleosynthesis process, then at least the major contributing processes must also have smooth abundance curves. Within errors, a smooth  $s$ -process abundance ( $N_s$ ) curve can be drawn using  $N_s$  from Beer and co-workers. For  $A = 75$ –85 there are strong "non- $s$ " contributions which could be flat or show a shallow maximum at mass 79–81. ( $N-N_s$ ; suppressed scale). This maximum would be analogous to the " $r$ -process" peaks at  $A = 129$  or 195. The reason that the two-peak structure for  $N = 50$  is not apparent in the total abundance curve is that the lower mass peak is relatively broad, leading to unresolved  $s$  and non- $s$  peaks in the total SSAC. The rise in the  $N-N_s$  curve below mass 75 is probably an error in the theoretical  $N_s$ , so the "non- $s$ " peak is better defined than at first glance. Below mass 69 it is hard to separate the contributions of  $n$ -capture nucleosynthesis from the high-mass tail of the iron group nuclei, the origin of which is not well understood.

In the mass 70–100 range the even- $A$  SSAC is not smooth and shows a sawtooth structure. From the point of view of identifying CI abundances with the average solar system it is not necessary that the even- $A$  curve be smooth. It is sufficient that the odd- $A$  curve is smooth. For even- $A$  the  $N_s$  show similar structure to the total SSAC. The product of  $N_s$  and stellar-temperature neutron capture cross section ( $\sigma$ ) is a slowly varying function of mass number except near neutron shells. The sawtooth structure is found in  $\sigma$  for even- $A$  nuclei on the  $s$ -process path. There is thus a strong suggestion that the sawtooth structure is an  $s$ -process feature. However, quantitatively, the literature  $N_s$  are insufficient to account for the sawteeth. One possibility is simply that the calculated  $s$ -process abundances are low, but a speculative alternative is that  $n$ -rich nuclear statistical equilibrium nucleosynthesis contributes significantly to SSAC in this region. This previously has been invoked to explain the relatively frequent occurrence of meteoritic isotopic anom-



alies in  $^{48}\text{Ca}$ ,  $^{50}\text{Ti}$  and  $^{54}\text{Cr}$  [3]. References: [1] D. S. Burnett *et al.*, submitted to *Geochim. Cosmochim. Acta* [2] D. Woolum (1988) In *Meteorites and the Early Solar System* (ed. Kerridge and Matthews). [3] D. Papanastassiou (1986) *Ap. J.* **308**, 27.

**The Carbon Components in Murray Residue CF.** I. P. Wright,<sup>1</sup> R. D. Ash,<sup>1</sup> M. M. Grady,<sup>1</sup> C. T. Pillinger<sup>1</sup> and M. Tang.<sup>2</sup> <sup>1</sup>Planetary Sciences Unit, Department of Earth Sciences, Open University, Walton Hall, Milton Keynes, MK7 6AA, England. <sup>2</sup>Enrico Fermi Institute, University of Chicago, Chicago, IL 60637 USA.

A recent ion probe study (1) of individual grains in a chemical/physical separate (CF) prepared from the Murray meteorite has shown there to be two carbon components present: C $\delta$  (diamonds) and a form of SiC. The measurements made by ion probe are consistent with the sampling locations having very low Si/C ratios being diamond with low  $\delta^{13}\text{C}$  ( $-38\%$ ; ref 2). Extrapolating the carbon isotopic data from  $-38\%$  to the outliers in the data distribution with Si/C ratios of 1 suggests the presence of SiC of  $\delta^{13}\text{C}$  between  $+600$  and  $+1500\%$ , although no  $\delta^{13}\text{C}$  values  $> +1000\%$  were measured during the study. C $\delta$  is known to burn at  $T < 550^\circ\text{C}$  (2, 3); SiC, even if fine-grained, ought to be more stable. Therefore, an apparently straightforward two-component sample such as CF would appear to be an ideal candidate for analysis by stepped combustion which should resolve the true isotopic compositions of C $\delta$  and SiC. Such an investigation would also greatly facilitate the interpretation of stepped combustion data from less highly processed acid residues. Stepped combustion of CF shows two substantial releases of carbon which are well resolved in terms of combustion temperature (200–500  $^\circ\text{C}$  and 1000–1200  $^\circ\text{C}$ ) consistent with the two component model (1). The ratio of low/high temperature component is approximately two. Carbon isotopic data for the high temperature component reach a plateau with three consecutive values of  $\delta^{13}\text{C}$  within  $\pm 15\%$  of  $+1370\%$ , suggestive of a single entity. The combustion temperature of C $\delta$  is known to be low (2, 3), hence the high temperature component is inferred to be SiC; it may be C $\beta$  the host of  $s$ -Xe known to be in CF (1). Stepped combustion of commercial SiC polishing powder (F600 grade, 3–19  $\mu\text{m}$ ) produced a release of carbon at 1100–1200  $^\circ\text{C}$ , the higher temperature of combustion reflecting a coarser grain size than the mineral present in Murray (*ca.* 0.1 to 0.2  $\mu\text{m}$ , ref 4). The  $\delta^{13}\text{C}$  value of the SiC in CF ( $+1370\%$ ) is *ca.* 400% heavier than any of the grains measured by ion probe, suggesting that the ability of the ion probe to resolve the individual components is compromised by the size of the primary beam, which is far larger than the size of the grains under study.

Over the temperature range at which the low temperature carbon is released no measurements were obtained which would accord with C $\delta$  having a  $\delta^{13}\text{C}$  of  $-38\%$ . The 400–550  $^\circ\text{C}$  region gave values of  $+4\%$  to  $+161\%$ . Assuming C $\delta$  has a  $\delta^{13}\text{C}$  of  $-38\%$ , as indicated by previous investigation of residues rich in this component (2), then the presence of a minor low temperature isotopically heavy carbon component is inferred which combusts at the same temperature as the diamond. Given that the release profile for carbon during stepped combustion of CF suggests a two-component mixture, and moreover indicates a major difference in the stability of these components to combustion, then a